Coordination Challenges in Operating-Room Management: An In-Depth Field Study

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Abstract: *Dynamic settings possess complex information needs all requiring attention in order to be managed effectively. The following study describes the multi-faceted information exchanges essential for an operating room suite to be managed within the context of efficient, cost effective, safe practice. Through the combined use of observation, the Critical Incident Technique, and interviews, this study analyzed information issues that impact coordination. Results demonstrate how distributed team planning is inherent to the efficacy of the system, and discuss implications for information tools to support coordination within in a complex setting.*

INTRODUCTION

Management of operating rooms (OR) requires the coordination of human and material resources in such a way that surgery can be performed efficiently, cost effectively, and safely. Annual cost estimates for surgical errors in 1999 were between $8.5 and $17 billion,[1] with medical errors attributed to system-related errors, such as coordination breakdowns.[2] Coordinating an efficient OR schedule balances cost containment, safe practice and staff satisfaction within a context of continual change, minimizing the consumption of "over-utilized OR time".[3] Voigt[4] notes that the increased number of surgical patients receiving care in outpatient or same-day surgery settings has required greater coordination efforts by OR personnel in managing daily operations.

Decisions involving OR coordination require input from multi-disciplinary stakeholders. Inter-disciplinary collaboration and consensus from key players is facilitated by avoiding hierarchical or formal power structures, committing to promoting equality and collective responsibility[5] and working for the attainment of group goals. Previous studies[6-7] noted that participants, within environments in which planning is disbursed among many people, engage in distributed team planning. Within these domains, one decision can have multiple effects, making well-coordinated decisions paramount. In the specific domain of an OR suite there are multiple stakeholders each possessing access to privileged information vital to the coordination of the OR. An OR suite was chosen for the current study to demonstrate the issues impacting decision making within a dynamic environment affected by distributed team planning because a concerted effort by a dedicated coordinator is required in order to ensure a safe and efficient schedule of cases on any given day. The dynamic setting requires decisions to be made based on oftentimes incomplete or sporadic information resulting in repercussions that propagate throughout the system.

Computation and communication technology have the potential to improve group decision-making, increase efficiency, attain staff satisfaction, and promote the provision of safe patient care. However, to realize that potential requires a deep understanding of group decision-making processes, and the probable impact of computer decision-support tools on the system. Studies in a wide variety of dynamic environments,[8-12] have shown a complicated picture of the coordination processes and coordinative artifacts, such as public display boards, used by distributed team members as decision support tools.

Prior studies of OR management have evaluated the role of the charge nurse[13] and whiteboard.[14] These observational studies examined the communication patterns of the charge nurse and the role of a public display board for OR management. The current study expanded the scope of investigation, and assessed all key players involved in the peri-operative process. In conjunction with observation, the Critical Incident Technique (CIT)[15] was used to enhance the understanding of the issues surrounding the exchanges of information and the effects the interchanges had on the management of the OR. CIT evaluates extremes of behavior within an environment from the stakeholders' perspectives. Through the use of CIT, observations, and in-depth interviews, the study focused on the flow of communication and the coordination challenges. This approach was employed because observation alone may not provide the insight required to understand the complex cognitive elements impacting the changes to the daily plan as displayed on the whiteboard. The combination of methods revealed issues effecting the coordination of information and provided important data regarding design implications for information technology tools.

METHODS

Observations of the management of information flow within a suite of six operating rooms were performed in a Level I trauma center. Only patients experiencing traumatic injury are admitted to this hospital but the admission may be scheduled via several routes or emergent thus increasing the chaotic nature of the environment. The OR staff is comprised of registered nurses, nursing assistants, scrub technicians and unit secretaries, all supervised by an OR charge nurse. The charge nurse collaborates with the OR staff, surgeons, anesthesia care providers, ancillary staff, facilities personnel and outside equipment suppliers in order to facilitate patient movement within the OR suite.

Observations of communication among and between the OR personnel and other hospital departments were performed by two observers (one a registered nurse) at the apparent hub of the information exchanges for the OR schedule i.e.: the dry-erase display board or "whiteboard." Twenty-four hours of observational data was collected between the hours of 6 a.m. and 4 p.m. because these hours are generally the busiest. However, observation alone did not provide clarity regarding the multifaceted negotiation required to achieve a surgical schedule for the day.

To enhance this initial collection of data, an abridged form of CIT was employed. Through a series of probing and clarifying questions personnel whose position impacted the OR's daily operations, were asked to provide examples of instances when daily plans were successfully executed and examples of instances when plans failed. Respondents were asked to specifically note factors that influenced the success or failure. This data was then synthesized with the data obtained via observation.

Synthesis of the data from both observation and CIT resulted in a preliminary information flow map that highlighted six dimensions for each observed activity: goals, process initiators, input and output media, data content, and the issues that disrupted the daily OR schedule. The disruptions were particularly relevant to the resultant activity because the confusion provoked the initiator of the process to deviate from his or her agenda and seek out additional information based on the disruption in order to attain the desired goals for the day.

Further analysis of the disruptions that were clarified within the information flow map produced a taxonomy of coordination challenges grouped according to the major components of the peri-operative process. Through the methodology employed, it was discovered that the charge nurse's goal for the day was to establish an initial plan based on the official schedule contained in the hospital information system. The plan should allow for completion of all requested cases and fully utilize all ORs staffed for the day. However, disruptions routinely required additional information and reformulation of the plan.

The methods used in this study also revealed the means of information exchange utilized by the primary components within the process. Assessing the information attainable by the charge nurse through these means, provided examples of information needs and disruptions related to the exchange of information.

RESULTS

The techniques employed in this study resulted in an information flow map that, after analysis, identified primary components of coordination processes, which formed the basis for a taxonomy of challenges within the setting. Further examination of the data identified information needs and schedule disruptions, provided examples of perturbations and information failures, evaluated current methods for collaborative exchange and identified efforts for coordination.

Observations and Interview

Observations generated 199 discrete event-scenarios that provided a means to evaluate the factors influencing the OR management process. The CIT and observations produced a catalog of the disruptions that forced additional coordination efforts and introduced breakdowns in coordination.

The components identified within the taxonomy included room availability, patient condition, equipment availability, etc (See table 1). Disruptions of sub-components on the day of surgery were routinely observed to require an alteration in the schedule and additional information to reformulate the plan. When the coordination efforts failed to provide each requisite component of the process i.e., an anesthetist, a surgeon, a patient, equipment and nursing support, then a case did not commence. Coordination of this process drew upon input from many different team members to exchange information. This exchange of information continued as the plan changed based on input from the various components.

Analysis of the exchanges observed revealed three means for accessing information. These were (1) information systems and documents, (2) direct

Table 1: Sources of information for coordination of the OR suite schedule, and their accuracy and accessibility.

Information Type [Accuracy/ Accessibility]	Information Systems and Documents	Direct Observation	Social Networks
Patient status	H/L	⊗	L/H
Patient room location	L/H	⊗	L/H
Scheduled surgery	L/H	⊗	L/M
Anesthesia staff status	⊗	H/H	⊗
Room staff status (e.g. technician, nurse)	⊗	H/H	⊗
Equipment status and location	⊗	⊗	M/M
Special needs (e.g. positioning, equipment)	H/L	⊗	H/L
Surgeon disposition and availability	⊗	⊗	M/M
Pending changes	⊗	⊗	M/H
Staff location and availability	⊗	H/M	M/H

H = High reliability and accuracy / High accessibility, easy to obtain; M = Medium reliability and accuracy / Moderate accessibility, Moderately easy to obtain; L = Low reliability and accuracy / Low accessibility, difficult to obtain;
⊗ = Not a prevalent method of obtaining information

observation and (3) social networks. Assessing the information obtainable by the charge nurse through each means provided for an illustration of information needs and disruptions to the information exchange process (table 1).

Information Needs and Disruptions

Information needs and disruptions were analyzed to elucidate the information required by the charge nurse to coordinate the OR schedule effectively (table 1). The "information type" listed in the table describes the type of content. The remaining columns indicate the broad classes for sources of information used to derive the information. Two letters are contained in each cell: the first describes the accuracy of the information attained from the given source (high, medium or low accuracy); the second letter describes the accessibility or availability of that information (highly accessible, moderately accessible or low accessibility or difficult to determine).

Information systems and documents include telephones, pagers, cordless phones and printed documents from both within the OR itself and the system as a whole, i.e., the pre-printed OR schedule for the day. Direct observations are those data points available to the charge nurse from directly observing the activity within the surroundings of the OR. Social networks note the complexities of the system requiring extensive efforts by the charge nurse to obtain required information from the system as a whole because many means are informal.

In evaluating the table note that there are trade-offs between accuracy and effort both within sources (patient status is accurate, but difficult to obtain), and between sources (equipment status may be accurate when available to be observed, but requires greater effort than relying on distributed knowledge, which can be less accurate). The inaccuracies or lack of obtainable data are perturbations necessitating extra effort to be expended on the part of the charge nurse in order to coordinate the OR schedule, as noted below.

Perturbations and Efforts to Obtain Information

Schedules were observed to be routinely re-worked as a result of changing or missing information. The information formally recorded in the information systems was often incomplete, or inaccurate, as a result of changes. For example, the official OR schedule in the information system (entered by the surgical scheduling office) contained a brief description of the surgery. From this information, the charge nurse and anesthesia charge person made assumptions regarding the requisite equipment and patient positioning needs. When the information was missing, they would attempt to contact the surgeon by phone, paging, or in person. If the surgeon could not be contacted in a timely manner, or if assumptions regarding the equipment or positioning needs were incorrect, the case was often delayed to accommodate the case's special needs. Equipment issues involved non-availability, cleaning prior to use, or simply set up time. This sometimes caused the case to be rescheduled or canceled. Delays and cancellations then propagated throughout the remaining schedule. Surgeons, anesthetists, and patient-unit nurses were then notified of a delay, and the changes noted on the whiteboard.

Collaborative Method of Information Exchange

Observations and CIT identified the OR whiteboard as a focal point in the schedule-maintenance efforts. As such, actors from all levels and user-groups converged at the board at various times, either explicitly for scheduling needs, or in passing. Because of the public nature of the board, it served as a repository for the distributed components of expertise and knowledge spread throughout the institution. One observed example of this distributed knowledge was as follows:

The attending anesthesiologist was walking by the schedule board and evaluated the planned cases. He then engaged the charge nurse to say

Table 2: An analysis of the components disrupting the coordination, the root causes of the disruptions, and methods of coping with the limitations or disruptions (remediation)

System Component	Problematic Aspects	Root Cause	Possible Remediation
Staff	•Availability, compatibility	•Fixed staff levels	• Preplanning, flexibility
Equipment	•Availability, location, status •Special needs not specified	•Scarce equipment shared throughout organization	• Planning, tracking
Information	•Inaccurate patient status, location or schedule information	•Patient stability •Dynamic nature of schedule	• Facilitate communication • Provide tools for status monitoring
Staff satisfaction	•Personality conflicts •Personal preferences •Political considerations	•Human nature •Inability to act professionally •Political climate	• Positive charge nurse coordination • Sensitive management • Conflict management
Schedule/ situation	•Changes (unexpected admission, etc) •Patient status change •Case process change (longer, shorter)	•Inherent in emergency medicine	• Flexibility of response • Adaptive team-based performance

that one of the cases would not be carried out today because of changes in the patient status. He also proffered an opinion that a second case would be canceled soon, and that a third case currently listed had been completed the day prior.

The complexity of coordination in a collaborative system that includes the diverse collection of domain specific experts, such as the OR, requires the opportunity for these actors to input their individual knowledge into the communal knowledge system i.e.: the whiteboard (see [16] for an in-depth discussion of this topic). The intricacy of the coordination was further evaluated by examining the components of the system to identify the problematic aspects of the process, the root causes for such problems and the potential means of remediation (table 2).

Efforts for Coordination

As noted above, the whiteboard served as one means of communicating the schedule of the day's events in the OR. However, as can be gleaned from the two tables, disruptions related to lack of information, inaccurate information or status changes impacting the schedule required collaborative efforts on the part of all components of the system to formulate or reformulate a plan. The charge nurse is critical to this information system because it is his/her responsibility to maintain the board as accurately as possible. In order to do so persuasion and politics are utilized not only to negotiate a plan for the day but also to do so in a manner that is satisfactory to all of the components involved. This is best demonstrated through an example of the use of the whiteboard as a spatially dispersed decision support tool.

Example: Surgeons scheduled to perform surgery were upset that their cases were not following one another in a given room. The surgeons began to recruit the aid of other staff to plead their case and the negotiations continued. In response to this behavior, the charge nurse placed cases not presently being performed in a "parking area" to provide visual appeasement to the surgeons by making the plan appear as if no surgeries were placed in assigned rooms as "scheduled."

Information Not Communicated Versus Unavailable

Coordination of a schedule was observed to break down due to reasons noted above, but also due to lack of information in the system. When surgeries were scheduled, the time to complete the procedure, the patient's status, the equipment and the positioning needs were to be noted. Observations revealed that this information could be helpful, disruptive or unavailable. For instance, the approximated time to complete the case was often extremely inaccurate. If so, the charge nurse, or anesthesia charge person often noted this based on prior experience with a particular procedure or surgical team. A change was then made immediately to both the timing of the case and the plan for the remaining cases scheduled.

When the patient status changed such that the surgery had to be rescheduled or canceled, this was communicated from the patient floor nurse to the charge nurse (initiated by the charge nurse). At times, this was also communicated from the anesthetist or surgeon to the charge nurse. Failure to communicate this information in a timely manner resulted in reorganization of the schedule for the day.

DISCUSSION AND CONCLUSION

Information systems currently provide only a fraction of the information necessary to adequately manage the changing schedule of the OR. Actors rely upon sources of information not typically examined by formal information-systems task and information analyses. For example, it was found that direct observation by the charge nurse was a reliable method of determining information pertinent to scheduling, though it required considerable time and effort on the part of the charge nurse. Authoritative sources of information were often the participants in the OR team, as opposed to the information systems.

Therefore, access to these key players was also crucial.

Furthermore, information contained in the informatics systems provided some information, but because of the dynamic nature of the OR schedule, this information was not always as accurate or as up to date as the informal sources of information i.e.: the social network. Coordination drew upon input from many different team members to exchange information continually as the plan changed based on input from the various components.

Information tools to support coordination in a dynamic and collaborative system such as the OR suite should include technologies and applications that support social networking and direct, real-time, perception of system status. For example, the use of remote viewing of key elements of the OR system via video signals could facilitate the direct perception of real-time system status. Communication technology could possibly facilitate social networks, and communal displays support collaborative work.

Methodologically, combining the CIT method with direct observations provided a more powerful tool for determining information flow patterns, content, and requirements, than observation alone. Ethnographic observation allowed immediate access to critical events, without introduction of retrospective recall biases inherent in the pure CIT methodology. The in-depth follow-up interviews supplemented these incident analyses with insight into the idiosyncrasies of the coordination process of the OR.

Although this is a limited investigation of a single site, both the methodologies and the specific findings may be applicable to many other settings, and could be applied to any system with dynamic, collaborative coordination tasks. Findings show the diversity of human information gathering and distributed cognition, not limited to traditional informatics systems. Based on the information presented here, information systems developed for complex, dynamic settings should take into account the diverse and varied information needs of the system-actors, and their need for multiple sources of information.

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